

What is claimed is:

CLAIMS

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1. A haptic feedback interface device in communication with a host computer implementing a host application program, said interface device manipulated by a user, the interface device comprising:

a device housing that is physically contacted by said user;

a sensor device detecting said manipulation of said interface device by said user, said sensor device outputting sensor signals representative of said manipulation;

an actuator coupled to said device housing, said actuator operative to output a force; and

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a mechanism coupling said actuator to said device housing, said mechanism allowing said actuator to be moved with respect to said device housing, wherein said actuator acts as an inertial mass when in motion to provide an inertial force that is transmitted to said user, wherein said mechanism includes at least two separated portions, each of said portions coupled to a different portion of said actuator.  
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2. A haptic feedback interface device as recited in claim 1 wherein said force output by said actuator is a rotary force.

20 3. A haptic feedback interface device as recited in claim 2 wherein one of said separate portions of said mechanism is coupled to a rotating shaft of said actuator, and another of said portions is coupled to a housing of said actuator.

4. A haptic feedback interface device as recited in claim 1 wherein said actuator is approximately linearly moved with respect to said device housing to provide a linear inertial force, said movement caused by said force output by said actuator.

25 5. A haptic feedback interface device as recited in claim 1 wherein said actuator approximately linearly moves approximately along a z-axis substantially perpendicular to an x-y plane in which said user can move a manipulandum of said interface device.

6. A haptic feedback interface device as recited in claim 1 wherein said actuator is coupled to a contact member such that when said actuator is moved, said contact member is

5 moved, wherein said user physically contacts said contact member in normal operation of said interface device, said contact member transmitting a contact force to said user while said inertial force is transmitted to said user.

7. A haptic feedback interface device as recited in claim 6 wherein said contact member includes a cover portion of said interface device, said cover portion being at least a portion of a top surface of said interface device.

8. A haptic feedback interface device as recited in claim 1 wherein said mechanism includes a flexure having at least two flex joints.

9. A haptic feedback interface device as recited in claim 8 wherein one of said portions of said flexure includes a rotating member coupled to said housing by a flex joint.

10. A haptic feedback interface device as recited in claim 9 wherein one of said portions of said flexure includes a collar coupled to a housing of said actuator and a flex joint coupling said collar to said housing.

11. A haptic feedback interface device as recited in claim 1 wherein said flexure includes at least one stop to prevent rotation of a shaft of said actuator past a desired fraction of a full revolution.

12. A haptic feedback interface device as recited in claim 1 wherein said actuator is moved bi-directionally to produce pulse and vibration sensations to said user.

13. A haptic feedback interface device as recited in claim 1 wherein said interface device is a handheld interface device.

14. A haptic feedback interface device as recited in claim 1 wherein said interface device is a mouse.

15. A haptic feedback interface device as recited in claim 14 wherein said inertial force is correlated with a graphical representation displayed by said host computer, wherein a position of said mouse in said planar workspace corresponds with a position of a cursor displayed in said graphical representation.

16. A haptic feedback interface device as recited in claim 1 further comprising a microprocessor, separate from said host computer, coupled to said sensor and to said actuator, said microprocessor operative to receive host commands from said host computer and output force signals to said actuator for controlling said inertial force, and operative to receive said sensor signals from said sensors, process said sensor signals, and report locative data to said host

computer derived from said sensor signals and indicative of manipulation of said interface device.

17. A haptic feedback interface device as recited in claim 14 wherein said interface device is operated on a pad, said pad providing compliance between said device and a hard surface supporting said pad, wherein said compliance magnifies said inertial force.

18. A haptic feedback interface device in communication with a host computer implementing a host application program, said interface device manipulated by a user, the interface device comprising:

a device housing that is physically contacted by said user;

a sensor device detecting said manipulation of said interface device by said user, said sensor device outputting sensor signals representative of said manipulation; and

an actuator assembly coupled to said device housing, said actuator assembly comprising:

an actuator; and

a flexure coupling said actuator to said device housing, said flexure allowing said actuator to be moved with respect to said device housing, wherein said actuator acts as an inertial mass when in motion to provide an inertial force that is transmitted to said user, wherein said flexure includes at least two separate portions, each of said portions coupled to said actuator, and each of said portions including at least one flex joint.

19. A haptic feedback interface device as recited in claim 18 wherein said force output by said actuator is a rotary force, wherein one of said separate portions of said mechanism is coupled to a rotating shaft of said actuator, and another of said portions is coupled to a housing of said actuator.

20. A haptic feedback interface device as recited in claim 18 wherein said actuator is approximately linearly moved with respect to said device housing to provide a linear inertial force, said movement caused by said force output by said actuator.

21. A haptic feedback interface device as recited in claim 18 wherein one of said portions of said flexure includes a rotating member coupled to said housing by a flex joint.

22. A haptic feedback interface device as recited in claim 21 wherein one of said portions of said flexure includes a collar coupled to a housing of said actuator and a flex joint coupling said collar to said housing.

23. An actuator assembly for providing inertial sensations in a haptic feedback interface device, the actuator assembly comprising:

an actuator; and

a flexure coupling said actuator to said device housing, said flexure allowing said actuator to be moved with respect to said device housing, wherein said actuator is operative to act as an inertial mass when in motion to provide an inertial force that is transmitted to a user of said haptic feedback interface device, wherein said flexure includes at least two separate portions, each of said portions coupled to said actuator, and each of said portions including at least one flex joint.

24. A haptic feedback interface device as recited in claim 23 wherein said force output by said actuator is a rotary force.

25. A haptic feedback interface device as recited in claim 24 wherein one of said separate portions of said mechanism is coupled to a rotating shaft of said actuator, and another of said portions is coupled to a housing of said actuator.

26. A haptic feedback interface device as recited in claim 23 wherein said actuator is approximately linearly moved with respect to said device housing to provide a linear inertial force, said movement caused by said force output by said actuator.

27. A haptic feedback interface device as recited in claim 23 wherein one of said portions of said flexure includes a rotating member coupled to said housing by a flex joint.

28. A haptic feedback interface device as recited in claim 28 wherein one of said portions of said flexure includes a collar coupled to a housing of said actuator and a flex joint coupling said collar to said housing.

29. A haptic feedback interface device as recited in claim 24 wherein said actuator is moved bi-directionally to produce pulse and vibration sensations to said user.

30. A method for providing inertial haptic sensations using a haptic feedback interface device in communication with a host computer, said interface device manipulated by a user, the method comprising:

5 enabling a detection of said manipulation of said interface device by said user, said sensor device outputting sensor signals representative of said manipulation;

enabling an output of a force with an actuator; and

10 causing said actuator to be moved with respect to said device housing using a mechanism coupled between said actuator and a device housing, wherein said actuator acts as an inertial mass when in motion to provide an inertial force that is transmitted to said user, wherein said mechanism includes at least two separated portions, each of said portions coupled to a different portion of said actuator.

31. A method as recited in claim 30 wherein said force output by said actuator is a rotary force.

15 32. A method as recited in claim 30 wherein said actuator is approximately linearly moved bi-directionally with respect to said device housing to provide a linear inertial force, said movement caused by said force output by said actuator.

33. A method as recited in claim 30 wherein said mechanism includes a flexure having at least two flex joints.

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